

## **Step 1: Understanding the Problem**

(Translating Math into English, and vice-versa)

1. The first thing to do is to read all the way through the problem without doing anything fancy just so you can get a basic idea of what the problem is about and start to understand the context of the question.
2. Read through the problem again, this time every time you come across a number (used as a value for a variable or as a description of a relation between two things) write down the number including what it is applied to. (Example: The distance from the Earth to the moon is 384,000 kilometers.)
3. Go through the numbers/relations you wrote down and translate them into mathematical formulas...

This last step is what we will explore in more detail here. Often the translation will be straightforward when the quantity is given in terms of a “normal” unit (such as kilometers, or years, or grams, or whatever). Here’s a very straightforward example:

*My friend, Alex, is 20 years old.*

Here the translation from English to a mathematical formula is fairly clear:

$$Age_{Alex} = 20 \text{ years}$$

Here we have just replaced the “is” in the sentence with an ‘equals’ sign. Also, note the usage of a subscript to explain what the variable belongs to. This is quite useful to keep things straight when the problems become complicated.

But other times the quantity will be given/defined in terms of another quantity. In these cases we need to learn some of the mathematics vocabulary. Lets look at an example. The sentence:

*My aunt is twice as old as Alex.*

is a way to define the age of my aunt in terms of my friend’s age. If we then wanted to translate this sentence into a formula we could write:

$$Age_{Aunt} = 2 \times Age_{Alex}$$

And so, by plugging in Alex’s age, we can find that:

$$Age_{Aunt} = 2 \times 20 \text{ years} = 40 \text{ years}$$

Now lets say that

*My cousin’s age is half of Alex’s [age].*

The translation is similar to the last example:

$$Age_{Cousin} = \frac{1}{2} \times Age_{Alex}$$

In these last two examples we have not only replaced the *is* with an equals sign (=) but also replaced the *twice/half* with their numbers, and replaced the final *as/of* in the sentence with the multiplication sign (×).

Sometimes the problem is asking for a piece of the formula, for instance:

*What fraction of my aunt’s age is Alex?*

So we can apply the same translation rules we’ve learned so far to figure out what the question is asking for numerically. Replacing the *is* with =, and replacing *of* with ×, and abbreviating *f* for the fraction we’re asked for gives:

$$f \times Age_{Aunt} = Age_{Alex}$$

In the previous problems we haven't had to use a variable since the previous sentences have given numbers rather than here where we are asked for the number. Solving our new equation for  $f$  (see [Algebra.doc](#) for help) gives us the answer:

$$f = \frac{Age_{Alex}}{Age_{Aunt}} = \frac{20 \text{ years}}{40 \text{ years}} = \frac{1}{2}$$

Thus we see (rephrasing our answer into English) that,

*Alex's age is half of my aunt's.*

If asked for *How many times my aunt's age is Alex?* The same analysis would apply and could be summarized by saying that *Alex's age is 0.5 times my aunt's age.*

Okay, lets look at a few more astronomy-related examples:

*The Earth's mass is three millionths of the Sun's mass.*

Here we have defined the mass of the Earth **in relation** to the mass of the Sun. This can be translated to the following equation using the same guidelines as before:

(see [Notation.doc](#) for help) 
$$M_{Earth} = \frac{3}{1,000,000} M_{Sun} = 3 \times 10^{-6} M_{Sun}$$

Or instead, if a question/problem asked you:

*How many times more massive is the Sun than the Earth?*

This could be re-written as: *The Sun is how many times more massive than the Earth?*

OR: *The Sun is X times more massive than the Earth. What is X?*

And then either of these could then be translated into the following equations:

$$M_{Sun} = X \times M_{Earth}$$

$$X = ?$$

And with some algebra it could be determined that:

$$X = \frac{1,000,000}{3} = 333,333$$

So we could say (replacing  $X$  in the above sentence) that:

*The Sun is 333,333 times more massive than the Earth.*

Using these methods of translation you should be able to figure out what a word problem is trying to tell you and what it is asking you to do; however, sometimes problems are poorly or confusingly worded. For instance, the problem:

*There are two planets in orbit around the star Curulis.*

*Their masses are half and then half again of one thousandth of Curulis' mass.*

*What is the ratio of the first planet's mass to the second planet's mass?*

Here the second sentence is very poorly worded.

In a situation like this it's important to remember that as long as you've spent a few minutes trying to figure out what a problem is saying/asking and if you are still having trouble with a specific part, the instructor or your TAs will be happy to help you interpret/translate that part of the problem. When going to ask for help, try to ask specific (rather than general) questions if you can, for instance:

*I'm having trouble understanding what this second sentence is saying.*

As compared to something general like:

*I don't get this problem.*

Which is much less impressive and will elicit a much less helpful response (if any) from the person you ask.